Human Reliability Analysis in Support of ASCAP Model of CBTM

Presentation to PTC RSAC

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Major Goals of HRA Study

- Develop and document HRA tools for use in railroad risk assessment applications
- Demonstrate the HRA tools using ASCAP analysis of CBTM in dark territory as a case study
- Iterate with RSAC & ASCAP on refining the process and methods, to ensure consistency of analysis

HRA Approach

- Qualitative Evaluation of Human Factors Issues
- Survey of databases for HRA sources
- Trial Quantification Workshop
- Second Quantification Workshop
- Document process & issues in application

Workshop

- 2 days in Greenville S.C.
  - October 29 & 30, 2001
- 30 attendees
  - 4 railroad & associated consultants
  - 13 labor & associated consultants
  - 6 FRA & associated consultants
  - 1 UVA
  - 6 Volpe & associated consultants
- Performed training, analyses of crew exceedances & CBTM as single group
- Split into 2 groups for other analyses

Analytical Process

- Identify major classes of failure
  - E.g. train passes limit of authority
    - Crew error
    - Dispatcher error
- What is scope?
- What kinds of things could cause this?
- What data exist?
- What judgments are needed?
- Synthesize analysis

Example: Crew-caused Exceedance of Authority

- Scope
  - Crew fails to stop at end of current authority
  - Possible reasons:
    - Inattention or fail to recognize location
    - Erroneous recall of authority
    - Distraction (within cab/out of cab)
    - Over-reliance on another crew member
    - Misjudged braking performance
    - “Unconscious”

Data & Basis for Analysis

- Data sources
  - Train crew disciplinary actions
  - CSX operating experience
  - Incidents in CBTM test territory
- Judgments required
  - Degrees of under-reporting
- Interpretation of results
  - Relationship to ASCAP CBTM Model

Overall Process

- Evaluate separate sources
  - CSX-wide experience
    - Larger volume of data
    - Less directly associated with test territory
  - CBTM territory experience
    - Much less data
    - Directly related to territory
- Integrate results
- Click here for flow diagram

CSX Crew Disciplinary Data

- 91 track segment (TS) violations in last 4 years
- Fraction in DTC territory
  - Pro-rated by track miles
    - About 37% of CSX is DTC
- Degree of under-reporting
  - Estimated 5-20% by participants
    - Assumed equally likely in this range
    - Mean is 12.5%
- Estimated TS violation in DTC per year = 9.5/year

CSX Experience

- Total main line train miles = 81.5E+6/year
  - Average over 4 years (1997 – 2000)
- Average DTC Train miles = 30.4 E+6 (~37%)
- Therefore *average* rate of exceedance = 9.5/30.4 E+6, = <u>3.1 E-7/train-mile</u>
- *(Will be adjusted to per block boundary soon)*

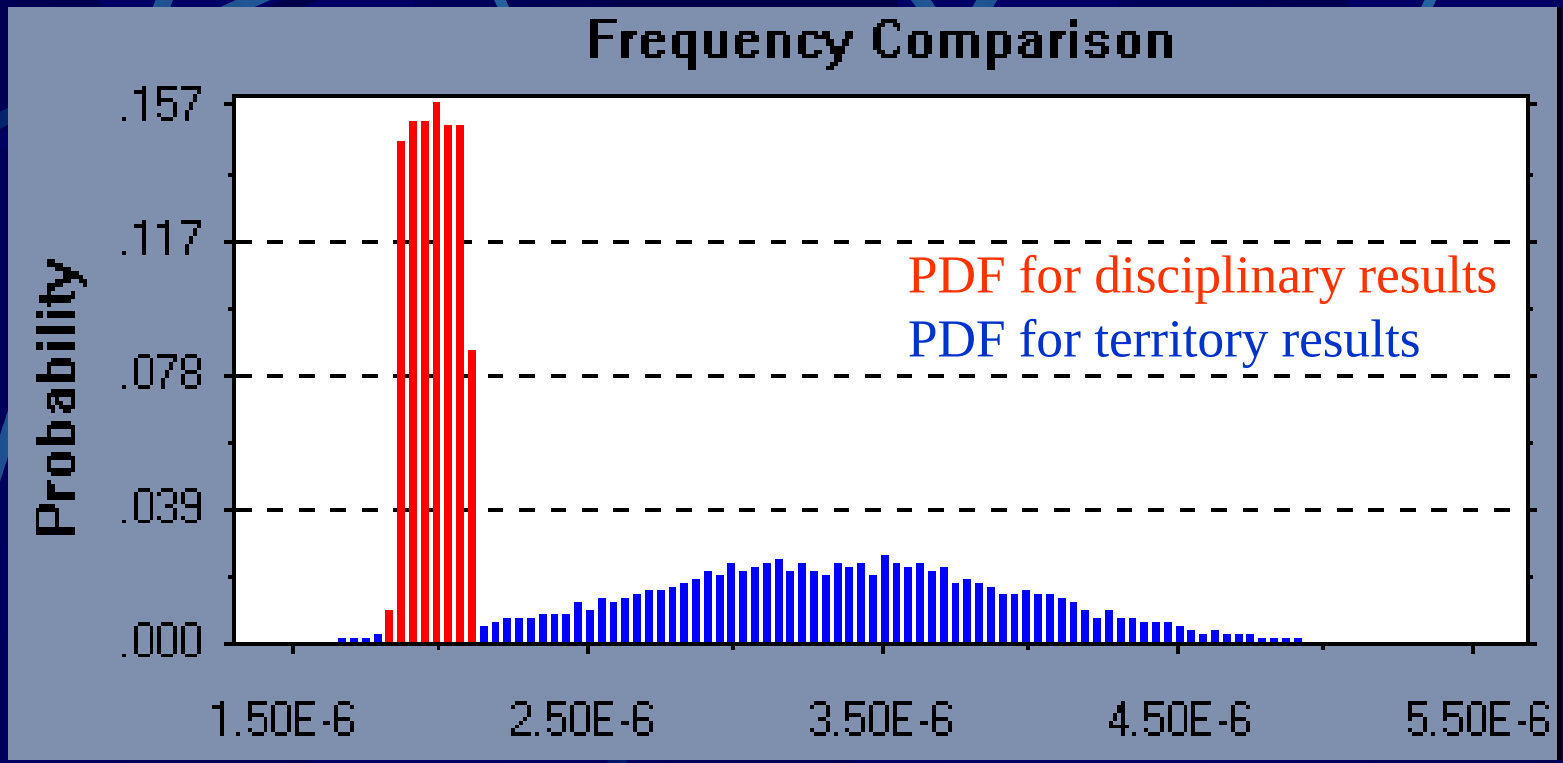
Territory-Specific Analysis

- No. of events within territory in database = 0
- Estimated occurrence rate = 3 to 6 in 10 years
  - Mean rate = 0.45 / year
- Sample operating experience showed 273 trains in 2 week period in territory
  - 855,000 train-miles/year (120 miles, 52 weeks/year)
- Average authority = ~2 blocks (or ~13 miles)
- Mean rate / authority = 6.7 E-6/authority issued
- Mean rate / train mile= 5.3 E-7/train-mile

Final Analysis

- Average block length = 6.3 miles
- Mean rate per block boundary
  - Disciplinary-data based = 2.0 E-6/block boundary
  - Territory-data based = 3.3 E-6/block boundary
- Which to use?

Comparison between Estimates



Distribution ranges overlap, with territory-specific encompassing disciplinary data. *Use territory result*.

Performance Shaping Factors (PSF)

- Workshop participants identified the most important PSF:
  - Experience Level
  - Weather
  - Quality of radio reception
  - Workload
  - Fatigue

Summary of Mean Results

- Crew-caused exceedances = 3.3 E-6 / block
- Dispatcher-caused exceedances = 1.7 E-6 /block
- Overspeeding = 4.0 E-6 / speed-zone
- Unauthorized workzone entry = 3.3 E-6 / zone
- Switches:
  - Switch left in reverse position = 1.6 E-4
  - Engineer fails to see switch & stop at track speed
    = 1.0 for 7 southbound & 6 northbound switches (because of location)
    = 0.2 for 3 southbound & 4 northbound switches
  - Engineer fails to see switch & stop at slow speed = 1.0 E-4

CBTM Results

- Likelihood of crew not responding before penalty brake, mean = 0.04/warning
  - Assuming warning/braking time, audibility issues, etc., resolved in production system
- Likelihood of crew not responding to events previously modeled (exceedances, overspeeding, etc.) is unchanged by addition of CBTM *if CBTM is failed:*
  - *Under operating philosophy that crews will be trained & expected to run as if CBTM does not exist*
    - i.e., No reliance on CBTM
  - *Will require active management involvement to accomplish this*

Evaluation of Reliance on CBTM

- Evaluate as sensitivity analysis
  - Increase failure probabilities for each ‘base case’ for events that CBTM provides coverage by factors: 2, 5, 10 …
  - Identify when reliance effects negate CBTM effectiveness
- Provides a basis to estimate margin before degradation of system occurs

Integrating PSFs into Human Reliability Quantification

- Workshop participants quantified the actions for the PSFs currently applicable to the CSX Augusta-Spartanburg run.
- The effects of PSF are not always simple multipliers.
- New elicitations are recommended for changed conditions.

Future Considerations for HRA

- Add new data and update distributions as experience grows
  - Should narrow distributions
- CBTM estimates have limited experience
  - More test experience should improve analysis
  - Values based on current expectations as to how system will be used

Workshop Comments

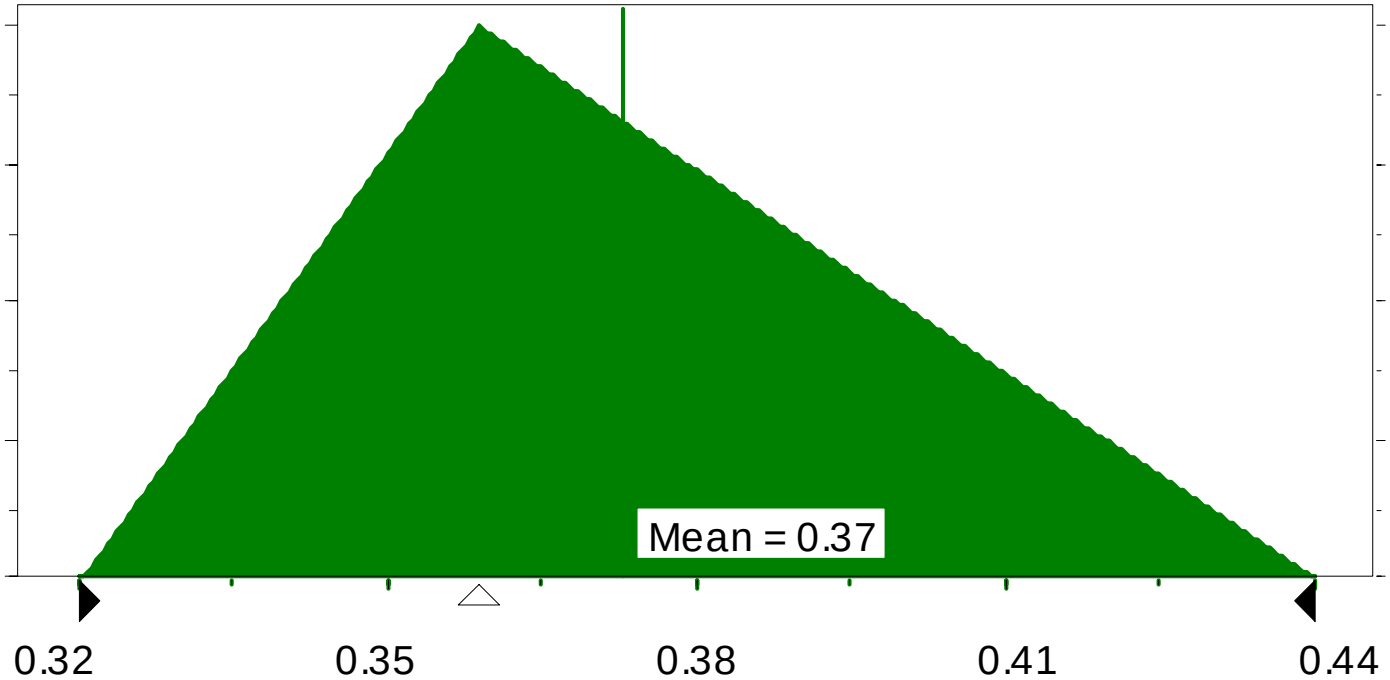
- The process was a useful and practical way to get local knowledge and expertise into the modeling process
  - Ensure that the inputs are only from the experienced people, not “just everyone”
- While the process was intense (and sometimes frustrating), the products reflect the effort
- Much qualitative discussion was needed to get to the quantitative results
  - ensures a common viewpoint between parties who normally see just one perspective
    - e.g., the details of switching operations, dispatching

Thanks

- To all attendees for their willingness to tolerate being pushed to where they might not realize they had knowledge and relevant experience
- To the labor representatives for their encouragement of active participation by members
- To the railroads for providing data and helping understand the operating issues and history
- To the FRA for supporting the workshop and encouraging the free flow of information in the potentially controversial area of human errors and railroad safety

The End

Fraction of CSX track that is DTC



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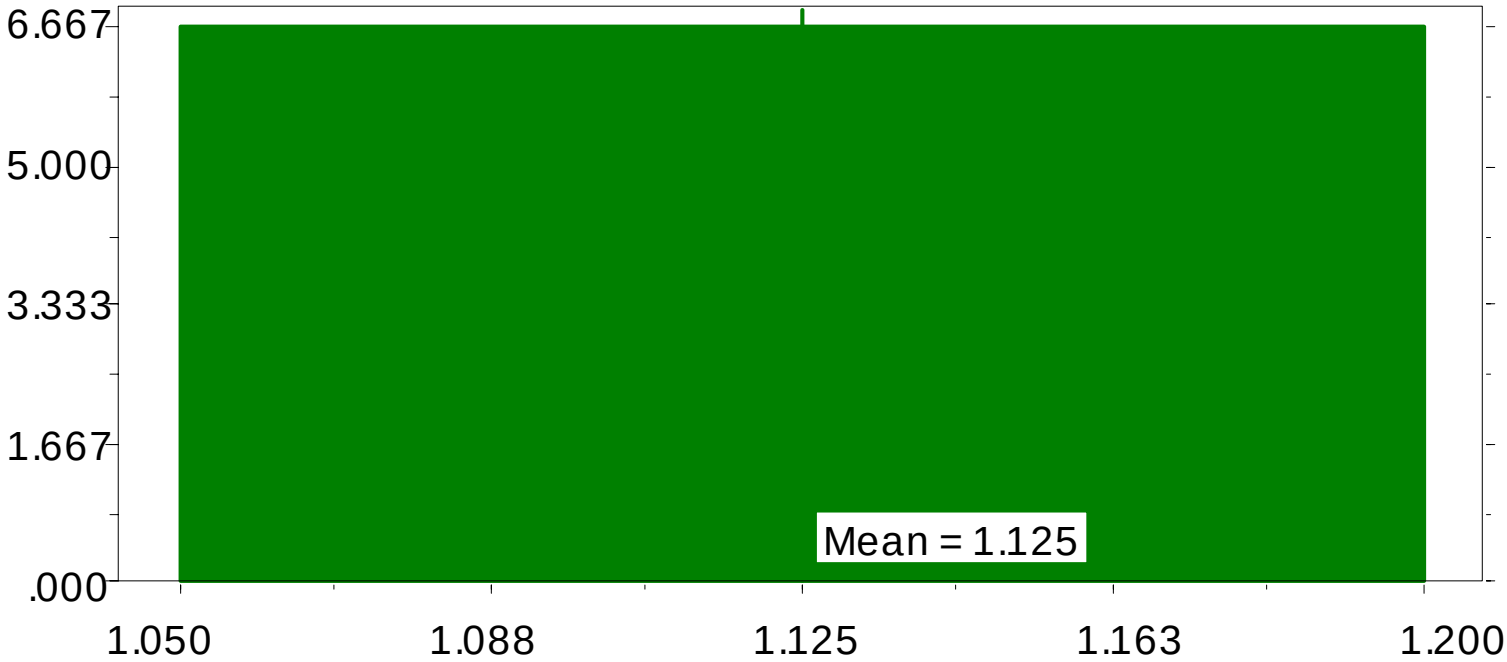
Extent of Under-reporting



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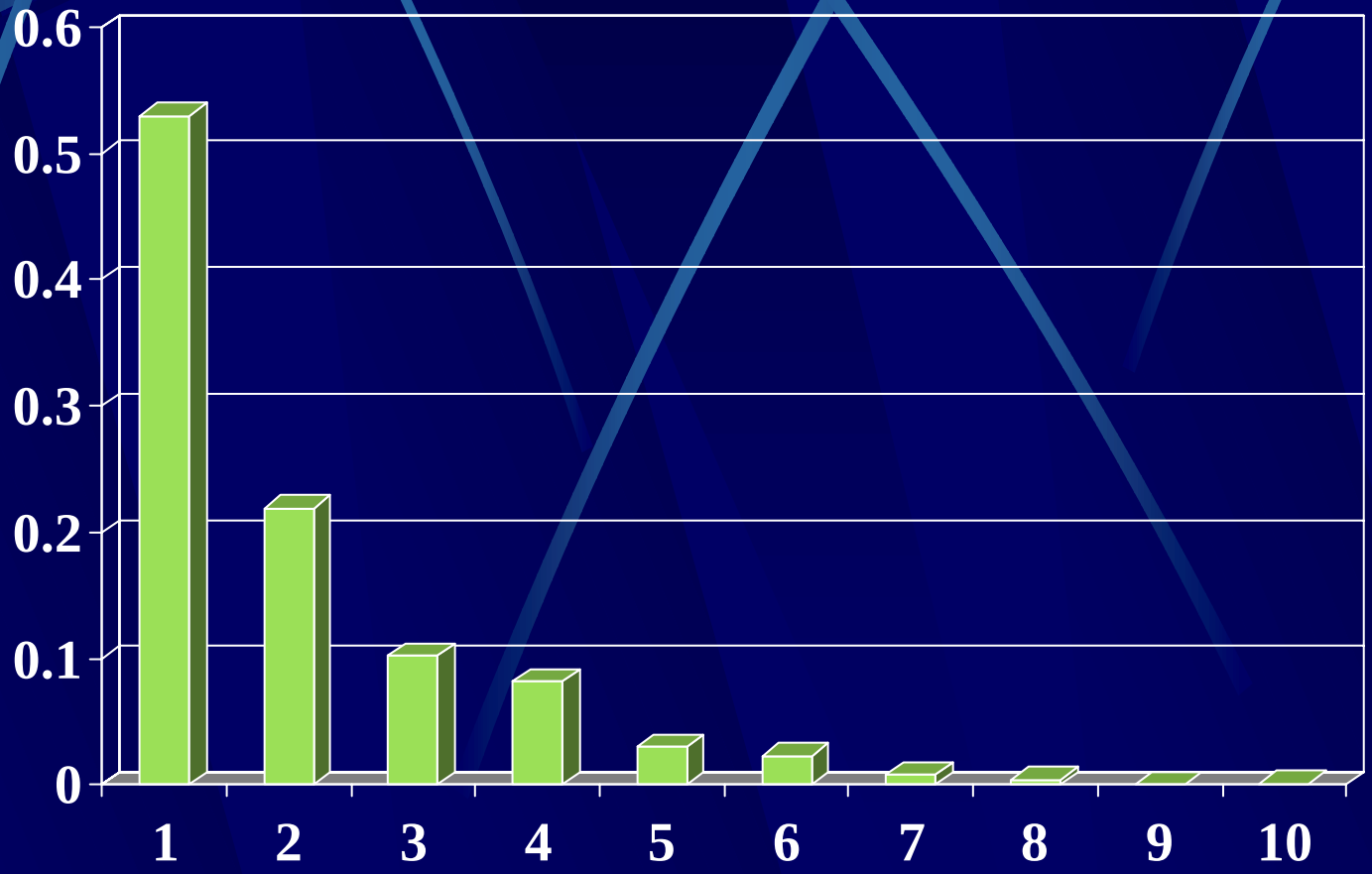
Distribution of No. of Blocks/Authority



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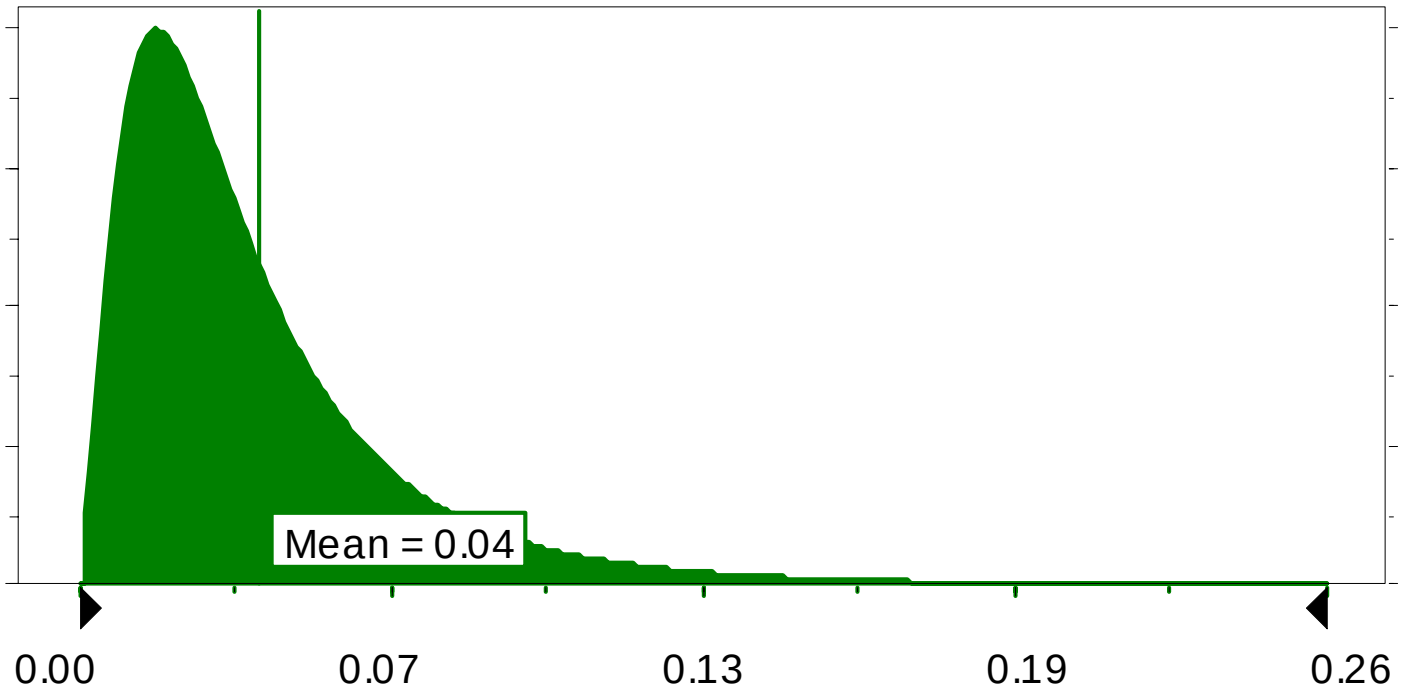
CBTM Response Model



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